tion. However, caution must be exercised in the discrimination of organic materials from porosity. Heavy metals can be used to "spike" organic materials for greater BSE visibility and differentiation from pore space.

The application of BSE imagery to the study of carbonate components is obvious and well shown in chapter six. The authors rightly argue that the study of dolomite and calcite cement stratigraphy should be studied using BSE imagery, and present many fine photographs to prove their point. Chapters seven and eight deal with the more specific topics of desert varnish and glauconite formation.

The volume ends with chapter nine dealing with image analysis, almost to the extent of being an image analysis short course. Issues such as the advantages of direct digital capture versus conventional photography are discussed. It is clear that digital capture is preferable overall, although conventional photography is still generally better for publication. For image analysis, digital BSE files give far truer renderings of the grey-scale gradations necessary to characterize mineral assemblages, amorphous materials, and porosity than do scanned conventional BSE image photographs. One great advantage of digital BSE files is that they may be "stacked" with corresponding digital EDX element concentration files in multilayer files acquired during the same SEM operating session to provide more comprehensive and accurate assessments of what is shown in the BSE images.

There are a few zingers. On page 7 the electron backscatter coefficient "0" is said to be proportional to beam strength for atomic numbers less than 47 and *vice-versa* for higher atomic numbers, but the graph on this page clearly shows the opposite. A little more serious is a statement on page 88 where the dissolution of carbonate minerals is related to "an increase in pore water pH" owing to an episode of decarboxylation. Most readers will recognize that increases in pore water pH will tend to favour precipitation, rather than dissolution, of carbonates. There are few, if any other, mistakes of this type.

An overall deficiency of the volume is the absence of case studies where BSE images have been used as one of many components in geological problem solving. It would have also been helpful to see more complementary SEM images, such as EDX images, accompanying the many illustrated BSE images, as well as optical microscope views of some lower resolution images. The authors come dangerously close to providing a simple atlas of BSE images, contrary to their stated purpose, but they do succeed in the end in demonstrating the wide range of data types that can be obtained by use of BSE images.

Many workers will recognize the great potential of BSE images as adjuncts to their own work. This book succeeds admirably in demonstrating how BSE imagery might be applied in new ways. This handsome book is priced at US$80.00. Not everyone will find it necessary to have this book, but, alternatively, no one will regret adding it to their overstuffed bookshelves.

## Past global changes and their significance for the future

**Edited by K.D. Alverson, F. Oldfied and R.S. Bradley**
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> When the logic of history hungers for bread and we hand out a stone, we are at pains to explain how much the stone resembles bread.
>
> *Aldo Leopold*

History certainly hungers for bread in the field of climatic change. Earth sciences are challenged to integrate disciplines of paleoecology, paloeoceanography, isotopic geochemistry, modern climatology and atmospheric modelling to shed light on natural variability and possible future climatic states. This volume has an ambitious title. Is it a loaf, or a stone?

Papers derive from a meeting of the IGBP (International Geosphere–Biosphere Programme) PAGES (Past Global Changes) project, University of London, 1998. The PAGES project is to,"provide a quantitative understanding of the Earth's environment in the geologically recent past and to define the envelope of natural environmental variability, against and alongside which anthropogenic impacts in the Earth System may be assessed" (Alverson and Oldfield, 2000, p. 3). These authors outline the components of the volume, and also introduce the reader to the many acronyms, nested under the grand acronym, PANASH (Paleoclimates of the Northern and Southern Hemispheres).

The volume's contributions are weighted to the Holocene (the last 10,000 years) and historic record, but there are eight papers spanning the last 100,000 years and up to 420,000 years. Thus the volume considers primarily the proxy records of high-frequency climatic events of the late Pleistocene and Holocene, and instrumental records of historic times. Tectonics and climatic change are considered only by An, in his discussion of the East Asian monsoon system. "Paleoenvironmental archives and methods" and "Pole-equator-pole" transects may be some of the most valuable sections to the geologically oriented reader. Raynaud *et al.* review high-latitude ice core records of atmospheric trace gas concentrations and isotopes, and their interplay with temperature changes on a time scale of up to 400 Ka. Raynaud *et al.* (2000, p. 10) state that, "The longer record indicates that the industrial increases of $CO_2$ and $CH_4$ are most likely unique in terms of growth rate and lead to present-day atmospheric concentrations which have been unprecedented over the last 420,000 yr." Regarding the effect of greenhouse gases and glacial-interglacial cycles, they observe that, "...changing the orbital parameters initiated the glacial-interglacal climatic changes, then the greenhouse gases amplified the weak orbital signal, accompanied several thousand years later by the effect of decreasing albedo during the retreat of the northern hemisphere ice sheets." (2000, p. 16).

Thompson reviews low-latitude ice core records, which produce evidence for cooler tropics during the last glacial cycle. Thompson includes a lament for the loss of the archives themselves, and points out the need to understand the variability of climate within 30° of the equator, where 75% of the world's people live. Hans Oeschger, to whom the volume is posthumously dedicated, provided a retrospective on global climatic change science since the 1950s, with a prescription for future work, including a call for a global monitoring network. Gagan *et al.* cover coral records of tropical paleoclimates over a historic to late-glacial time scale. De Vernal and Hillaire-Marcel compare modern and full glacial sea ice cover in the Labrador Sea, showing more extensive, but seasonally variable ice during the last glacial maximum. Briffa summarizes Holocene tree ring records from the northern and southern hemispheres, concluding that temperatures over the last century have been unusually warm compared to the last 2000 years, but adds a caveat regarding the effect of human activities on the tree ring record.

The Pole-equator-pole (PEP) transects are ambitious North and South hemispheric climatic comparisons. For PEP I, Markgraf *et al.* compare historic to late Pleistocene records on the west coasts of North and South America. Colinvaux *et al.* conclude that the Amazon was forested in glacial times, and vegetation has been stable through the Pleistocene. A discussion touching on tectonics and climate was An's contribution to PEP II, a review of the late Pleistocene history and variables driving the East Asian monsoon, attributing its development to late Tertiary uplift of the Tibetan Plateau. Records over the last glacial cycle show the instability in the East Asian monsoon system. Gasse also brings together a surprising wealth of information about changes in tropical African hydrology since 23 Ka, as part of the PEP III transect. Late Pleistocene–Holocene hydrological changes are "abrupt," reflecting complex interactions of several parameters.

Alley reviews the also abrupt climatic change of the Younger Dryas from the perspective of Greenland ice cores. It is a useful update, from a vital central record, of evidence for local and global climatic changes, although it is not a synthesis of a burgeoning body of literature. The end of the Younger Dryas is estimated at 11,500 yr BP, with duration of 1200 to 1300 years.

An IMAGES (International Marine Global Change Studies) contribution by Cortijo *et al.* considers North Atlantic climatic variability between 10 and 60 ka. Iceberg surges (Heinrich events) and climatic fluctuations (Dansgaard-Oeschger events) are also associated with decrease of ventilation of deep waters. They also conclude that there is, "...a threshold effect in the climatic oscillations linked to changes in the freshwater budget and heat transport affecting the ocean surface"(2000, p. 239). This paper is complemented by Leuschner and Sirocko's discussion of low latitude and Antarctic evidence of Dansgaard-Oeschger events during the last 100 ka.

In the section, "Paleoclimatic Modelling and Model Data Comparison," the tone changes to a more theoretical view of the nature, rate and causes of atmospheric and oceanic circulation changes and problems of simulation. The articles are no less worthy than the foregoing, but may be of somewhat less interest to the geologist, and I shall omit many of the papers from this review. However, within this section, Stocker addresses past and future reoranization of the climate system, considering the role of deep ocean circulation in regulating abrupt climatic changes. As a palynologist, I was pleased to see Stocker (p. 304) recognize that paleobotanical records first identified the climatic oscillations of the last deglaciation, especially the Younger Dryas.

The final section of the volume is titled "Holocene Environmental Change and the Human Dimension." Bradley provides a summary assessment of "Past global changes and their significance for the future." All of the climatic changes associated with the "Little Ice Age," from the coldest period of the 15th century to the warm period of the last 50 years took place within a range of about 0.5°C. This puts in perspective a low estimate expected temperature change of +1 to 2°C, by the end of the 21st century.

Beer *et al.* consider the role of the sun in climatic forcing, concluding that solar forcing is responsible for about 40% of the warming over the last 140 years. Zielinski discusses the differential effect on climate of volcanism in different latitudes, and the effect of volcanism on climatic forcing over different time scales. Knox chronicles the historic and Holocene flood history of the upper Mississippi Valley, and Messerli *et al.* consider the transition from nature- to human-dominated environmental changes.

The volume's authors have made synthetic contributions. The volume is an excellent review of the state of the art in paleoclimatology, useful for academics whose research interests or teaching requirements involve paloeclimatology. Production quality is high and typographic errors few. Many figures are in colour, and would make useful overhead figures for teaching. However, many figure captions are much too brief for the complex content of the figures. For students with an interest in climatology, the volume provides up-to-date reviews on various topics, and the reference lists are useful research sources. For policy-makers with some background in geology or paleoclimatology, it provides a good overview of what is known about natural climatic variability beyond the normal climatological time scale of a century or less. It is important to recognize the natural mechanisms of climatic change in addition to anthropogenic mechanisms..

Those who have a passing familiarity with Quaternary paleoclimatology, or even a specialty in one of the disciplines, may well be surprised by the degree of progress in data accumulation and synthesis, and the breadth of global coverage in the last decade. The work has done much to reveal the complexity of the question of climatic change, but simple, effective explanation will require many more years of endeavour. We cannot predict the future, but have made considerable progress in recognizing the natural variability in climate.

This volume provides excellent access to the results. It is bread, not a stone.